Modularity of Metal-on-Metal Hip Implants Increases Cobalt:Chromium Ratio

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Introduction: Due to its success, the use of total hip arthroplasty (THA) has been extended into younger age groups. In these patients, bone conserving implants are attractive. Unfortunately, these require metal-on-metal (MOM) bearings to provide the wear resistance needed. With resurfacings, metal ions are only released from wear at the bearing surface. However with MOM THA there is metal ion release from wear of the bearing surfaces as well as wear and corrosion at the head-neck taper. Blood metal ion levels may provide useful information regarding the production of metal debris in-situ. Conversely, current interpretation of blood metal ion levels are unable to provide information regarding the integrity of the taper modular junction. The aim of this study was to investigate whether there is a difference in blood metal ion levels and their ratios between implants with different modularities.

Methods: This was a retrospective, non-randomized study performed at a national implant retrieval and tertiary referral centre for MOM implants. To investigate the differences in blood metal ion levels between implants with different modularity’s, we identified all retrievals and patients referred with implants manufactured by MMT/Smith and Nephew with the same MOM bearing surface. A total of 501 patients had undergone a unilateral hip replacement with a Birmingham Hip (cobalt chromium alloy) bearing surface combination.
There were 306 resurfacings and 54 THAs, which had failed and were subsequently revised. Whilst, there were 106 resurfacings and 35 Birmingham Mid-Head Resections (BMHR) which were well functioning. Patient demographic data was collected for all implants. Whole blood cobalt (Co) and chromium (Cr) levels were collected and ratios calculated for all implants and

Results: In the failed THA group the median Cr level was 4.15ppb (32% > 7ppb) and median Co level was 7.25ppb (52% > 7ppb). In the failed resurfacing group the median Cr level was 6.60ppb (46% > 7ppb) and the median Co level was 6.08 ppb (47% > 7ppb). There were no statistically significant differences in blood metal ion levels between both groups. In the well functioning resurfacing group the median Cr level was 2.32ppb (6% > 7ppb) and median Co level 1.8ppb (8% > 7ppb), both significantly less than the failed resurfacing and THA groups (p 7ppb) and median Co level 1.95ppb (9% > 7ppb), both significantly less than the failed resurfacings and failed THA groups (p <0.001).
Co:Cr ratios for each group are illustrated in figure 1.
The mean Co:Cr ratio was significantly greater in the failed THA group (2.32:1, 95% CI 1.84:1 to 2.80:1) when compared to the failed resurfacing group (1.47:1, p<0.001). In the failed THA group 60% of Co:Cr ratios were greater than a 1.5:1 ratio, compared to only 28% in the failed resurfacings group. In the well functioning resurfacing group the mean Co:Cr ratio was 0.93:1 and the well functioning BMHR group Co:Cr ratio was 1.08:1. Although there was no significant difference between these groups they were both significantly less than the failed THA (p <0.001). Only the well functioning resurfacings Co:Cr ratio was significantly less than the failed resurfacings ratio(p=0.002).

Discussion: Metal debris from the bearing surface is a known complication of MOM bearings. However recently, failure of the modular taper junction has become a cause of concern in THA. Unfortunately there is no investigation that can currently provide information regarding the integrity of modular junctions in vivo. The utilization of individual blood metal ions provides a marker of the in-vivo performance of MOM bearings but the effect of modularity is unknown.

In this study we have shown that well functioning implants have lower blood metal ion levels than failed implants with the same bearing surface. However more importantly there was an increase in the Co:Cr ratio with increasing modularity.

There are studies that have shown elevated Co levels compared to Cr in modular implants. In a prospective randomized clinical trial Garbuz et al compared clinical outcomes of MOM resurfacings to MOM large diameter head THAs. At one year the THA group showed a marked elevation of Co in relation to Cr when compared to the resurfacing group. The elevation in the Co:Cr ratio may be due to the production of a Cr oxide passivation layer that develops at the head-neck junction, causing unopposed release of Co. However blood metal ion levels are also affected by material loss from the bearing surface. This influence will prove difficult to eliminate and possibly obscure any true relationship between blood metal ion levels and taper material loss. In this study, we have investigated implants with the same manufactured bearing surface but with different modularities. Although volumetric material loss from the taper junctions has not been ascertained we have found a significant increase in Co:Cr ratio in the THA group when compared to resurfacings and the BMHR.

We may have expected that because the BMHR also has a modular junction the Co:Cr ratio should be higher. However the tapers of the BMHR and the THA are different. The BMHR has a collar just below the taper for the head to sit on, which the THA doesn’t. This could potentially protect this taper from fluid and debris that can exacerbate corrosive material loss at this junction. Also, due to the geometry of the BMHR implant the forces that act through this are similar to a resurfacing and the implant is well supported by the native femoral neck. In contrast the THA undergoes forces, which are transferred through the implant and the unsupported taper junction allowing the potential for micromovement that exacerbates corrosion at the taper junction.

The increase of Co and Cr, especially in implants with a modular junction does not appear to be equal. In modular implants it appears that the Co increases more than Cr and this is likely due to the taper junction. The Co:Cr ratio could possibly be used to risk stratify implants which undergo taper failure. Therefore a possible alteration to the reporting of clinical reference levels used to monitor patients with implants that contain Co and Cr levels, should include a Co:Cr ratio.

Significance: The full significance of blood metal ion levels and their correlation with the in-vivo performance of MOM bearings are not fully known. There are a large number of MOM bearings, which have failed with blood metal ion levels less than 7ppb. However till more is known about the significance
of blood metal ion levels we cannot advise on how this value should be altered. This study showed a significantly higher Co:Cr ratio in patients with a MOM THA that may be attributed to metal debris from the modular stem-head junction. Further work is required to correlate retrieval analysis with blood metal ions to investigate the effect of material loss from modular junctions on blood metal ions and ratios.
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